UNCLASSIFIED

AD 419314

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA. VIRGINIA



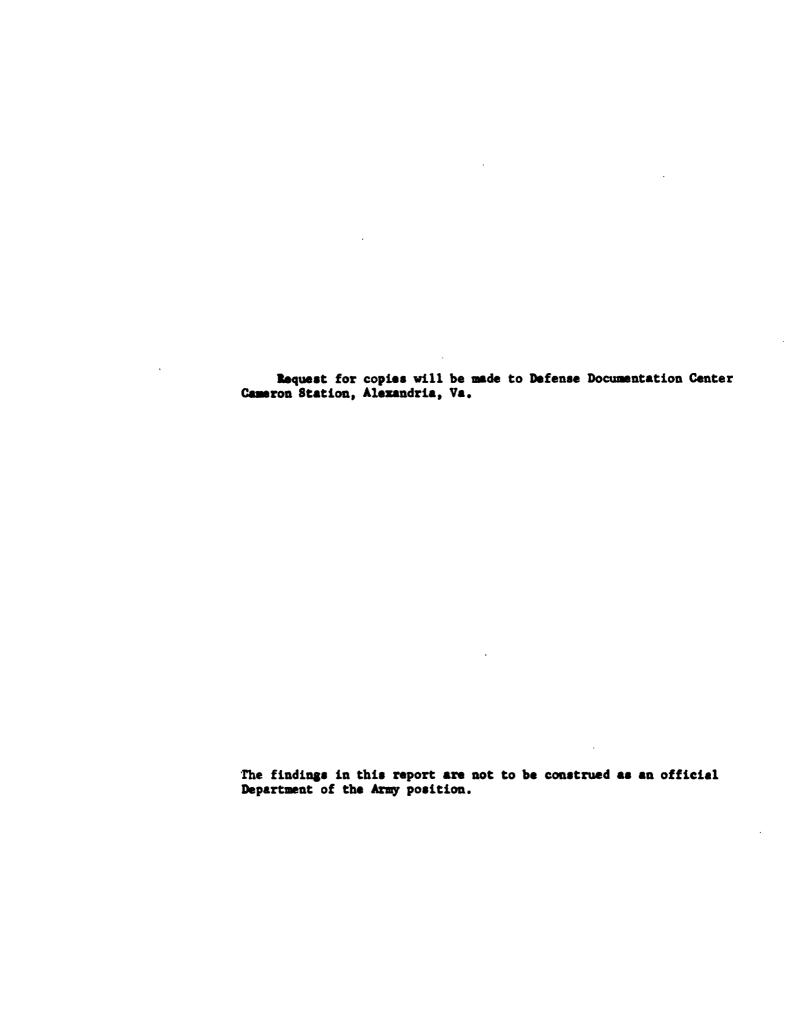
UNCLASSIFIED

Best Available Copy

MOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

PHILADELPHIA 37, PA.

E D STATES ARMY **FRANKFORD** CATALOGED BY ARSENAL 64-5 A STUDY OF MACRO-PARTICLE ACCELERATION WITH SEQUENCED HIGH EXPLOSIVE IMPULSES Optimization of Single Stage Geometry by WARREN B. FOGG July 1963 **CMS** Code 5520.11.434 DA Project 50201008 DDC APAPINOR REPORT M64-5-1 50151 v 62



FRANKFORD ARSENAL Research and Development Group Pitman-Dunn Institute for Research Philadelphia, Pa. 19137 MEMORANDUM REPORT M64-5-1 July 1963 OMS Code 5520.11.434 DA Project 50201008

A STUDY OF MACRO-PARTICLE ACCELERATION WITH SEQUENCED HIGH EXPLOSIVE IMPULSES

Optimization of Single Stage Geometry

Prepared by

Warren E. Fogg WARREN E. FOGG Physicist

Reviewed by

ER Thils
E. R. THILO

E. R. THILO Director

Physics Research Laboratory

Approved by

Deputy Director

Pitman-Dunn Institute for Research

ABSTRACT

A single stage high explosive system for accelerating macroparticles has been designed and tested in order to investigate the various parameters.

Velocities to 7500 fps were achieved with an aluminum projectile weighing approximately 4.5 grams. Damage to the projectiles became so great (mass losses to 40 percent) that the program was halted.

Suggestions are made to show how the methods of acoustical impedance matching could help prevent projectile break-up.

INTRODUCTION

It was desired to identify the sensitive variables in a single stage, explosive, shaped charge system which would be used as the first stage of a sequenced system for obtaining hypervelocity projectiles. The apparent simplicity of using sequenced explosive impulses from unlined shaped charges to attain hypervelocity projectiles (20,000 fps and greater) has aroused a great deal of interest at this installation. Previous efforts resulted in preliminary models of both a single and a two-stage launcher system.*

The results were encouraging. Velocities to 6,000 fps were achieved with the single stage launcher, and the two-stage system gave a boost of 40 to 50 percent to projectiles (4.0 to 4.5 gm) moving with an initial velocity of 4,000 fps. The recovered projectiles showed only slight evidence of mass loss and deformation due to action of the gaseous jet.

However, the results did show a serious shot-to-shot velocity variation with the single stage launchers. This could not be tolerated due to the precise timing which would be necessary for the second and successive stages.

The study reported here was undertaken as part of an effort to arrive at a single stage geometry which would give a maximum projectile velocity with a minimum shot-to-shot variation.

METHOD

The launcher designed for this study is shown in Figure 1. The lead encasement was cast around the steel barrel and a mandrel which formed the charge cavity and the launcher angle. The mandrels, one for each of the individual launcher angles, were machined with a tailpiece which supported the barrel during casting. This method was relatively inexpensive and assured good alignment between the charge and the barrel. The launchers weighed approximately 30 pounds, which was enough so that no elaborate anchoring fixtures were required. Most of the lead was recovered after firing and was re-used in the casting process.

Initially, it was intended that charges of various diameters would be investigated, but as the testing progressed, it was decided that no advantage would be gained by changing the charge size.

^{*}C.W.Fleischer, "A Projectile Launching System for Hyperballistic Studies," Proceedings of the First Army Science Conference, June 1957.

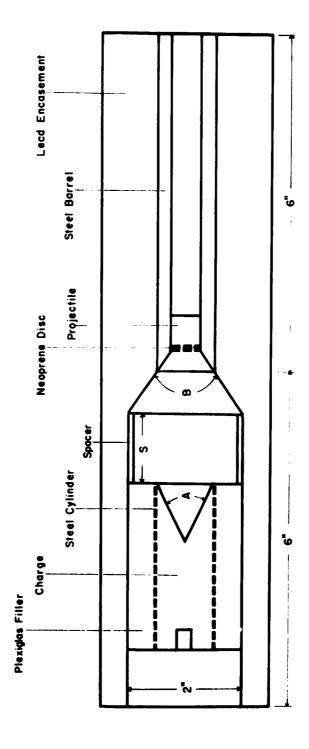


Figure 1. Single Stage High Explosive System

The charges used (1 inch in diameter and cast of 60/40 pentolite) were maintained at a constant weight of 69 grams.* To maintain the constant weight, the charge length was varied when the angle (A) changed. The charges were recessed along the axis at the rear to accept a tetryl booster pellet (1/4 inch diameter by 3/8 inch long). Detonation was initiated with a No. 6 blasting cap butted against the booster pellet.

The projectiles were machined from aluminum round stock to a nominal size of 1/2 inch diameter by 1/2 inch long. Since the barrels were made of steel tubing, as received, it was necessary to machine each projectile to fit a specific test barrel. Friction fit was maintained. The projectiles were partially protected with 1/8 inch thick neopreme discs which weighed 0.7 gram.

The standoff distance (S) was measured between the bases of the charge angle (A) and the launcher angle (B). At distances greater than zero it was maintained with steel spacers of the appropriate axial length.

Velocities were measured over a 2-foot base line. Velocity screens, continuous conductors printed on paper and connected electrically to an oscilloscope, were placed at the appropriate points to detect passage of the projectile. A voltage drop was indicated on the oscilloscope as each screen was broken by the projectile. The length of time necessary for the projectile to traverse the base line distance was measured with the sweep frequency of the oscilloscope. A Polaroid camera, attached to the oscilloscope, provided a permanent record.

The projectiles were recovered by firing into a box of sawdust. Deceleration in this manner did not damage the projectile.

Originally it was intended to fire a minimum of three tests for each change of one of the parameters (A, B, cr S) while holding the other two constant. As the testing progressed, much greater projectile damage was encountered than had been expected. The program was halted so that studies of the damage and methods of preventing it could be made.

EXPLORATORY TESTS

During the testing program, brief exploratory tests were conducted in an effort to either gain a velocity increase or prevent

^{*}This weight was based on a charge 3 inches long with cone angle (A) of 60°.

excessive projectile damage. The results are not conclusive, but they are included for a matter of record and to give some indication of trends that were observed.

The launcher was modified by eliminating the angle B. This allowed a further check on the effects of standoff distance. However, velocities increased and projectile damage was extreme and, therefore, the short standoffs cannot be used until a method is devised for protecting the projectiles.

Smaller steel projectiles were tested to increase the velocity. Drill rod (1/4 inch by 1/4 inch) and 1/4 inch diameter bearings were tried. The cylinders were nested in one end of an aluminum projectile, and nylon sabots were machined for the bearings. The velocities achieved, 7,000 to 9,000 fps, were satisfactory and the bearings suffered only slight damage. However, mass loss of the cylinders ranged between 16 and 50 percent.

Attempts to decrease projectile damage by using stronger material were equally unsuccessful. Steel cylinders (1/2 inch by 1/2 inch) and 1/2 inch diameter steel bearings were tried. The velocities decreased sharply due to the increased projectile mass, and mass loss ranged between 50 and 80 percent. The cylinders had been treated so that their tensile strength was approximately 250,000 psi.

Preliminary investigations to test the method of acoustic impedance mismatching were made. A pad or pads of different materials whose acoustic impedance differed greatly from that of aluminum was/were placed between the projectile and charge. The following materials were used either singly or in combinations: 1/8 inch aluminum discs, 1/2 inch aluminum slugs, 1/2 inch cellular aluminum slugs, 1/8 inch and 1/4 inch neoprene discs, 1/8 inch and 1/4 inch nylon discs, 1/2 inch glass slugs, and 1/8 inch lead discs. None of these was entirely satisfactory. The loss of mass still averaged 60 percent, and the velocities decreased with each increase of additional mass to be accelerated. Combinations of aluminum and nylon showed the most promise.

RESULTS AND CONCLUSIONS

The individual test conditions, comparison of projectile weight before and after firing, and the recorded velocities are given in Table I. Figure 2 shows a sampling of the recovered projectiles.

Although the testing was conducted in the open atmosphere, no efforts were made to establish data for drag reduction. However,

TABLE I. Recorded Projectile Velocities and Comparison of Projectile Weights Before and After Firing

Test	в <u>(°)</u>	S <u>(in.)</u>	Projectile Before Firing	Weight (gm) After Recovery	Velocity x 10 ⁻³
			nange Angle = 60		
1	60	0	4.2		7.50
2	60	0	4.2		7.02
3	60	0	4.2		7.27
4	45	0	4.2	3.9	7.02
5	45	0	4.2		5.59
6	45	0	4.2		7.41
7	45	0	4.2		7.09
8	30	0	4.5	3.5	7.14
9	30	0	4.5	3.6	6.89
10	30	0	4.5	3.7	7.02
11	60	0.5	4.4	3.7	5.00
12	60	0.5	4.4	3.8	6.45
13	60	0.5	4.4	3.7	5.80
14 15	60 60	0.5 0.5	4.4 4.4	3.9	5.88
16	45	0.5	4.5	4.0 3.6	4.63 6.25
17	45	0.5	4.5	3.6	6.35
18	45	0.5	4.5	3.7	6.34
19	30	0.5	4.4	3.7	6.90
20	30	0.5	4.4	3.8	6.67
21	60	1.0	4.4	3.9	5.24
22	60	1.0	4.5	3.8	5.17
23	60	1.0	4.5	3.6	5.26
24	60	1.0	4.5	3.8	5.33
25	45	1.0	4.4	3.8	5.68
26	45	1.0	4.4	3.9	5.56
27	45	1.0	4.4		5,59
28	30	1.0	4.4	2.8	6.35
2 9	30	1.0	4.4	3.8	6.12
30 31	30 30	1.0	4.4	3.6	6.01
32	30	1.0 1.0	4.4 4.4	3.6 3.8	5.95 5.36
		Ct	marge Angle = 45	5°	
33	45	0	4.4		6.49
34	45	Ŏ	4.4	3.7	7.29
35	45	ŏ	4.4	3.5	7.18
36	45	Ö	4.4	3.7	5,65
37	45	Ó	4.4	3.8	6.67
38	45	0.5	4.5	3.5	5.60
3 9	45	0.5	4.5	3.6	5.00
40	45	0.5	4.5	3.7	5.80
41	45	1.0	4.4		5.36
42	45	1.0	4.4	3.7	5.71
43	45	1.0	4.4	3.8	5.48
44	45	1.0	4.4	3.7	5.29
		Cł	narge Angle = 30)°	
45	30	0	4.5	3.5	5.88
46	30	0	4.5	3.6	5.88
47	30	0	4.5	3.7	6.15
48	30	1.0	4.5	3.7	5.18
49	30	1.0	4.5	3.6	5.20
50	30	1.0	4.5	3.5	5.48

Figure 2. Sampling of the Recovered Projectiles shown with an Unfired Slug for comparison (Velocities in fps and other test conditions are given)

to gain some insight as to how much reduction might have been experienced, the standard equation

$$v = v_0 \exp -(\rho d^2 K_d z/M)$$

was applied to samples of the test firings using the values:

$$o = 4.35 \times 10^{-5} \text{ lb/in.}^3$$

z = 2 feet, and

Kd varied between 0.1 and 1.0.

The maximum reduction was found to be three percent.

Figures 3 through 6 show the average recorded velocities plotted against the effective standoff, Se. Se is defined as the distance between the bases of the projectile and the charge angle. From an examination of these figures one can infer that the maximum velocity will be achieved with a set of parameters in which the charge angle (A) equals 60° .

The function of the launcher angle (B) and its relation to the standoff distance is least understood. The effective standoff (Se) increased when B was decreased. It was expected that projectile velocities would decrease with increasing standoff, but Figure 5 shows that this is not always true. This graphs shows a decided velocity increase in two cases when B is decreased while holding A and S constant. Apparently there is some additional focusing of the peripheral gases which is due to angle B and which is dependent upon the standoff distance.

The shot-to-shot velocity variation within the different groupings might present a problem when successive stages are added, but this would depend upon the configuration chosen.

The amount of damage suffered by the projectiles is so serious, it warrants special attention. It arises from two separate and distinct sources. The first, erosion due to the jet itself, is apparently of little consequence. The major damage is due to scabbing of the projectile material. The longitudinal compression pulse, produced in the projectile upon impact by the jet, traverses the material and gives rise to a reflected tensile stress pulse at the front surface. The superposition of these two pulses exceeds the tensile strength of the material and, therefore, the projectile is literally torn apart. The mechanism as presented here is highly simplified, but the results suggest that a careful analysis of the stress wave propagation, interaction, etc, within the system is necessary.

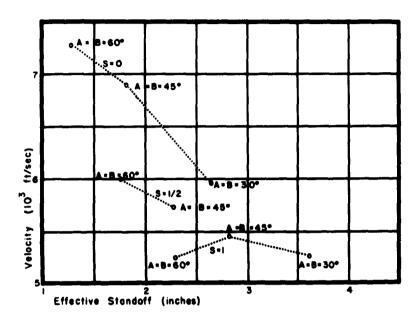


Figure 3. Plot showing how both Velocity and Effective Standoff vary with Changes in the Angle when the Charge and Launcher Angles are Equal

36.231.S1854/ORD.63

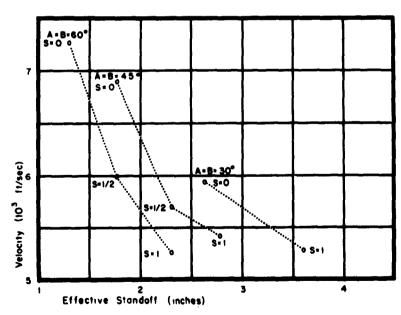


Figure 4. Data of Figure 3 plotted to emphasize the Effects of varying only Standoff Distance

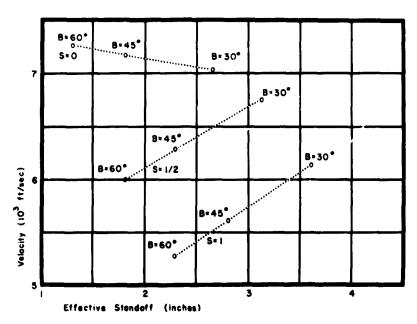


Figure 5. Plot showing how Variations of Launcher Angle effect both Velocity and Effective Standoff
(Charge Angle is 60° throughout.)

36.231.S1856/ORD.63

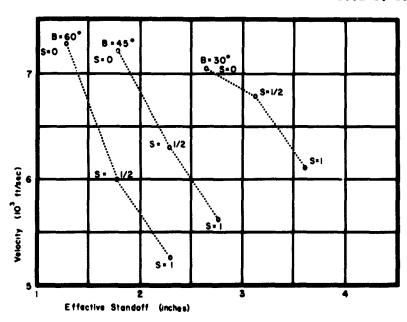


Figure 6. Data of Figure 5 plotted to show Effects of varying only Standoff Distance
(Charge Angle is 60° throughout.)

FUTURE WORK

Additional effort should be directed primarily toward a means of preventing excessive projectile damage. A solution now under consideration would make use of the concept of acoustical impedance matching or, rather, controlled mismatching.

Ordinarily, impedance matching is used to prevent scabbing from the reverse side of a material which receives a sharp impulsive load. This is accomplished by backing the primary material with another which has the same acoustical impedance, or nearly so. The stress pulse produced upon impact then continues through the material and across the boundary with little or no reflected pulse arising; thus, fracture is prevented.

It is assumed that the reverse procedure can be adapted to the launching system. A pad or pads of different materials, greatly mismatched in acoustical impedance, placed between the projectile and charge would absorb or attenuate the initial peak pulse. The amplitude of the transmitted pulse would be less than that required to form a reflected pulse within the projectile sufficient to cause fracture. This padding would also prevent erosion of the projectile due to action of the jet.

In addition, high speed framing camera observation of the jet formation and propagation would undoubtedly yield valuable information for selection of an optimum S and B.

Finally, precisely cast charges should be tested for their effect on the shot-to-shot velocity variation. The charges used here were obtained from a small company (primarily concerned with commercial applications) which does not have facilities for controlled precision casting.

DISTRIBUTION

- 1 Hq, U.S.Army Materiel Command Attn: AMCRD-RS-CM-Bal Washington 25, D. C.
- 1 Attn: AMCRD-DE-MO
- 1 Attn: AMCRD-DE-MI
- 1 Attn: AMCRD-DE-W
- 1 Commanding General U.S.Army Munitions Command Attn: Technical Library Picatinny Arsenal Dover, N. J.
- 1 Commanding General U.S.Army Missile Command Attn: Technical Library Redstone Arsenal Huntsville, Ala.
- 1 Commanding General U.S.Army Weapons Command Attn: Technical Library Rock Island Arsenal Rock Island, Ill.
- 1 Director of Army Research Office, Chief of Research and Development Attn: Physical Science Div Washington, D. C. 20310
- 1 Commanding Officer U.S.Army Research Office-Durham Box CM, Duke Station Durham, N. C.
- 1 Commanding Officer Detroit Arsenal Center Line, Mich.
- 3 Commanding Officer Picatinny Arsenal Attn: Feltman R & E Laboratories Dover, N. J.

- 1 Commanding Officer Rock Island Arsenal Rock Island, Ill.
- 1 Commanding Officer Watertown Arsenal Attn: WAL Watertown 72, Mass.
- 1 Commanding Officer Springfield Armory Attn: Res.4 Div, - T.I.V. Springfield 1, Mass.
- 1 Commanding Officer Harry Diamond Laboratories Washington 25, D. C.
- 1 Attn: AMXDO-TIB
- 1 Commanding Officer Biological Warfare Laboratoris Chemical Corps Research & Development Command Fort Deterick, Maryland
- 1 Commanding Officer U.S.Army Chemical Warfare Laboratories Army Chemical Center, Md.
- 1 Commanding General U.S.Army Engineer Research & Development Laboratories Attn: Technical Intelligence Branch Fort Belvoir, Va.
- 1 Chief of Engineers Department of the Army Attn: ENGNF - Mine Warfare Br Washington 25, D. C.
- 3 Chief, Bureau of Naval Weapons Department of the Navy Washington 25, D. C.

- 1 Director U.S.Naval Research Laboratory Attn: Technical Information Div Washington 25, D. C.
- 1 Commander
 U.S.Naval Weapons Laboratory
 Dahlgren, Va.
- 2 Commander
 Naval Ordnance Laboratory
 Silver Spring 19, Md.
- 1 Commander U.S.Naval Ordnance Test Station Attn: Technical Library China Lake, Calif.
- 1 Commander Air Force Systems Command Attn: SCRR Andrews Air Force Base Washington 25, D. C.
- 1 Commander Air Proving Ground Center Attn: PGTRI Eglin Air Force Base, Fla.
- 1 Attn: PGTW
- 1 Attn: PGTWR
- 1 Attn: PGTZ
- 1 Commander Aeronautical Systems Command Attn: Technical Library Wright-Patterson Air Force Base Ohio
- Director, Project RAND
 Department of the Air Force
 Attn: M.R.Anderson, Librarian
 1700 Main St.,
 Santa Monica, Calif.
- 1 Attn: Dr. J. H. Huth
- 1 Attn: Dr. R. D. Holbrook

- 1 Director
 National Aeronautics and Space
 Administration
 Attn: B. A. Nulcahy, Chief,
 Div of Research Information
 1520 H St., N.W.
 Washington 25, D. C.
- 1 U.S.Atomic Energy Commission Attn: Mrs. J. O"Leary (for Div of Military Appl) Technical Reports Library Washington 25, D. C.
- 1 U.S. Atomic Energy Commission Los Alamos Scientific Laboratory P.O. Box 1663 Los Alamos, N. M.
- 1 U.S.Dept of the Interior
 Bureau of Mines
 Attn: M. P. Benoy, Reports Librarian
 Explosives Research Laboratory
 4800 Forbes St.
 Pittsburgh 13, Penna.
- 1 Library of Congress Technical Information Division Reference Department Attn: Bibliography Section Washington 25, D. C.
- 10 Defense Documentation Center Cameron Station Alexandria, Va.
- British Joint Services Mission
 Ministry of Supply Staff
 Attn: Reports Office
 P.O. Box 680, Benj Franklin Statn
 Washington, D. C.
- 4 Defense Research Member Canadian Joint Staff (W) 2450 Massachusetts Ave., N.W. Washington 8, D. C.1 -
- 1 Applied Physics Laboratory The Johns Hopkins University 8621 Georgia Ave. Silver Spring, Md.

- THRU; Commanding Officer
 Los Angeles Ordnance District
 55 S. Grand Ave.
 Pasaden 2, Calif.
- TO: 1 Mr. Guy C. Throner
 Chief, Explosive Ordnance Sec
 Aerojet General Corporation
 Asuza, Calif.
- TO: 1 Dr. Louis Zernow
 Aerojet General Corporation
 Asuza, Calif.
- 1 Carnegie Institute of Technology Department of Physics Attn: Professor E. M. Pugh Pittsburgh 13, Penna.
- 1 Firestone Tire & Rubber Company Attn: Mr. C. M. Cox, Librarian Defense Research Division Akron 17, Ohio
- 1 Space Technology Laboratories, Inc.
 Attn: J. Maxey
 Los Angeles 45, Calif.
- 1 Attn: M. Greenfield
- 1 Technik Incorporated 50 Jericho Turnpike Jericho, N. Y.

ACCESSION NO. UNCLASSIFIED TABLE Described Development Group, Pleane I Merro-particle Acceleration 2. Shaped Garges II. Merro-particle Acceleration 3. Shaped Garges II. Merro-particle Acceleration 4. Magnetic Barges of the Acceleration 5. Shaped Garges II. Merro-particle Acceleration 5. Shaped Garges II. Merro-particle Acceleration 6. Shaped Garges II. Merro-particle Acceleration 7. Shaped Garges II. Merro-particle Acceleration 8. Shaped Garges II. Merro-particle Acceleration 9. Shaped Garges II. Merro-particle Acceleration 9. Shaped Garges II. Merro-particle Acceleration 9. Merro-particle Acceleration 1. Merro-particle A	A stage stage high explosive system for accelerating merro-particles has been designed and tested in order to investigate the various permeters. Velocities to 7900 Home; (pp ware exhered with an aluminum projecties wighing approx 4.5 grams. Demange to the projecties became so grant (mass losses to 40 percent) that the program was bailed. Suggestions are made to show how the methods of accountical impedance matching could help prevent projecties break-up.	1. Mecro-particle Acceleration 2. Shaped Charges 3. Explosive Devices I. FA Rev Méx-5-1, Jul 63 II. Marren B. Fogg III. Marren B. Fogg III. Marren B. Fogg III. As Foode 5220.11.434 Distribution i.DutyArron8: Nome; obtain copies from DCC. UNCLASSIFIED	AD. PARTOR ASSEMAL, Baserer and Development Group, Fitnen-Daminstitute for Baserer, Falledsighia, Fa., 1917 PA Bet Méd-5-1, Jul 63, "A STUPY OF MAND-PARTICE ACEL-ZRATION WITH SHOUNDED MINISTRY DEVIASS. Optimization of Single Stage Coometry," by Warren B. Pogg is tend tables 6 illus; ONG Code 520.11,434; DA. Froj 50201008 Unclassified Maport A single stage high emplosive system for accelerating macro-particism has been designed and teated in order to investigate the various parameters. Welocities to 7500 fps more achieved with an almainm projectiles to 7500 fps more achieved with an almainm projectile weighing appart 4.5 gream. Damage to the projectile weighing sprant (mass loases to 40 percent) that the program was halted. Suggestions are made to show how the mathods of accounting impedance matching could be by prevent projectile break-up.	UNCLASSIFIED 1. Macro-particle Acceleration 2. Snaped Charges 3. Emplosive Devices I. FA Rpt N64-5-1, Jul 63 II. Marren B. Fogg III. OWS Code 5520,11434 II. Marren B. Fogg III. OWS Code 5520,11434 III. Proj 90201006 DISTRIBUTION LIMITATIONS: Home; obtain copies from DDC.
	1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1	UNCLASSIFIED Merro-particle Acceleration Magned Charges Emplosive Devices Emplosive Devices Emplosive Devices Emplosive New Colone Merron S. Pogg DMS Code 5520.11.434 DMS Froj 50201008 Frigor LDMITATIONS; obtain copies from DDC.	AD. PERMITTAL, Research and Development Group, Fitnand Dame Institute for Lessarch, Fitladelphia, Fa., 19137 FA Ret Béd5-1, Jul 63, "A STUPT ON MACRO-PARTITULE ACEST. FA Ret Béd5-1, Jul 63, "A STUPT ON MACRO-PARTITULE ACEST. FINATION WITH SEQUENCE RICH EXTROSTY INVESTER & ACEST. FINATION OF Single Stage Geometry," by Warren B. Forg. IN pp itsel tables & illus; OH Gods 550.114.43; DA Froj 50201008 Weclassified Report A single stage high explosive system for accelerating macro-particles has been designed and tested in order to investigate the verticus parameters. Velocities to 7500 figures dass accelerated and tested in order to investigate the verticus parameters. Velocities to 7500 figures dass losses to 40 percent) that the program was balted. Suggestions are made to show how the mathods of acceleration breakers.	UNCLASSIFIED 1. Marro-particle Accelerati 2. Shaped Charges 3. Explosive Devices 11. Marres B. Fogg III. Marres B. Fogg III. GGG Code 5520,11,434 DISTRIBUTION LEMINATIONS: Home; obtain copies from DDC.

•

.

			fps were achieved with an aluminum projectils weighing approx 4,5 grame. Damage to the projectiles became so great (mass losses to 40 percent) that the program was halted.	DISTRIBUTION LIMITATIONS: macro-particles has been designed and tested in order to Discount copies from DDC. investigate the various parameters, Walcettee to 7500	I. FA Rpt M64-5-1, Jul 63 EARING WITH STORON BLOOM EXPENSIVE DRUCKES - Optimi- II. Warren B. Fogs III. Warren B. Fogs III. GPS Code 5520,111,434; DA Froj 50201008 III. GPS Code 5520,111,434; DA Froj 50201008 III. Proj 50201008 III. BA Froj 50201008	UNCLASSIFIED UNCLASSIFIED 1. Macro-particle Acceleration 2. Support Charges 3. Explost the Devices 11. Marren B. Forg 111. ORS Code 5520,11,434 DISTRIBUTION LUMITATIONS: Nome: obtain copies from DOC.	AD- FAMANCOM ANSEMAL, Research and Development Group, Pitchen- Dunn Institute for Research, Thiladelphia, Ps., 19137 FA Rpt M64-5-1, Jul 63, "A STUPY OF MACED-PARTICLE ACKEL- REALTION WITH SEQUENCES BITCHE EXTENSE THOUSED STATE IN PRINTED ACKEL- REALTION of Single Stage Geometry," by Watten B. Posig. IN PP incl tables & Illus; ONS Code 5520,11,634; DA Proj 50201008 Unclassified Report A single stage high explosive system for accelerating macro-particles has been designed and tested in order to inventigate the various parameters. Velocities to 7500 few ware achieved with an aluminum projectile weighing appare 4.5 grams. Damage to the projectile to 1500 few ware aloses to 40 percent) that the program was halted. Suggestions are made to show how the methods of accustical impedance matching could help prevent pro- jectile break-up.	1. Mero-particle Acceleration 2. Shaped Charges 3. Explosive Devices 1. FA Rpc M64-5-1, Jul 63 11. Merren B. Fogs 111. GGS Gode 5520,11434 DA Froj 50201008 1STRIBUTION LDHIATIONS: Nome: obtain copies from DDC.	
		UNCLASSIFIED UNCLASSIFIED AD. AD. ACCESSION NO. 1. Mecro-particle Acceleration 2. Shaped Charges 3. Explosive Devices 11. Na Rev N641, Jul 63 11. Navran B. Forgs 11. Merran B. Forgs 11. One Code 5250.11,434 Proj 50201008 A single stage high explosive system for accelerating merrans and texted in order to investigate the various parameters. Value in order to investigate the various prismate to 7500 if we war achieve dith an projectite to 7500 if we war achieved with an abundance or accelerating approve 4, parameters. Valuetites to 7500 if we war achieved with an abundance projectite to 7500 if we war achieved with an abundance projectite to 7500 if we war achieved with an abundance projectite to 7500 if we war achieved with an abundance polecitie to 7500 if we war achieved with an abundance polecitie to 7500 if we war achieved with an abundance polecitie to 7500 if we war achieved with an abundance polecitie to 7500 if we war achieved the projectite is became achieved and served in order to accelerating approve 4, parameters. Valueties became achieved the projectite to 7500 if we war achieved the projectite is bundance and served in order to accelerating approve 4, parameters. Valueties became achieved the projectite to 7500 if we war achieved the projectite to 7500 if we war achieved the projectite to 7500 if we wan achieved the projectite to 7500 if we have the war achieved the projectite to 7500 if we wan achieved the projectite to 7500 if we have the war achieved the projectite to 7500 if we have the war achieved the projectite to 7500 if we have the war achieved the projectite to 7500 if we have the war achieved the projectite to 7500 if we have the war achieved the projective to 7500 if we have the war achieved the war achieved the projective to 7500 if we have the war achieved the war achieved the war achieved the war achieved the wa	UNCLASSIFIED UNCLASSIFIED	UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED AD- Suggestion are made to show how the methods of acoustical impedance matching could help prevent projectils break-up. I. Macro-particle Acceleration Suggestion ACCESSION NO. ACCESSION NO. I. Macro-particle Acceleration PAMPTON ARSEMA, Massarch, Philadelphia, Pa., 19137 Suped Charges II. PA Age Watern B. Forge III. Office Acceleration Dura institute for Massarch, Philadelphia, Pa., 19137 A Single Stage Geometry, by Watern B. Forge III. Office Acceleration Dura institute for Massarch, Philadelphia, Pa., 19137 A Single Stage Geometry, by Watern B. Forge III. Office Acceleration A single stage high explosive system for accelerating macro-particles has been designed and tesser of notice to 7500 fivenes: obtain copies from DDC, investigate the various parameters. Valocities to 7500 fivenes: obtain copies from DDC, investigate the various parameters. Valocities to 7500 fivenes: and an acceleration and approx 4.5 grams. Damage to the projectile a became and an accelerating approx 4.5 grams. Damage to the projectile a became and an accelerating approx 4.5 grams. Damage to the projectile a became an acceleration of strain and acceleration of strain and an acceleration of strain and an acceleration o	NOCLASSIFIED UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED AD- ACCESSION NO. I. Asherd Angers ONCLASSIFIED ONCLASSIFIED AD- ACCESSION NO. I. Asherd Angers II. Asher New-5-1, Jul 63 III. Asherd Societies breath and Development Croup, Pitnam Development Development Croup, Pi		great (mass losses to 40 percent) that the program was halted.		ses to 40 percent) that the program was
	_	UNCLASSIFIED UNCLASSIFIED Necro-particle Acceleration Shaped Charges Steplosive Devices I. FA RET NGG-5-1, Jul 63 II. Marra B. Forg. II. Marra B. Forg. III. ORG Code 5520.11.434 III. ORG Code 5520.11.434 III. ORG Code 5520.11.434 III. Marra B. Forg. Unclassified Report AD ACCESSION NO. ACCESSIO	UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED VACEESSION NO. Shaped Garges Sapled Garges Taking of accession of accession for bear the matching could help prevent properties for accession of the properties of accession for the properties of accession for	UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED VAD: National Accession of security and the security of security and the security of security and the security of secur	DISTRIBUTION LIMITATIONS: None; Obtain copies from DDC, Investigate the various parameters, Velocities to 7500 from ware achieved with an aluminum projectile set to 7500 from ware achieved with an aluminum projectile became so great (mass losses to 40 percent) that the projectile became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became so great (mass losses to 40 percent) that projectiles became to 40 percent) that projectiles became and that the projectiles became and that that the appropriate and that the projectiles became and that the projectiles and that the projectiles and that the projectiles became and that the projectiles are always and that the projectiles are always and that the projectiles are always and that t	DISTRIBUTION LUMITATIONS: Nome; obtain copies from DDC.	A single stage high explosive system for accelerating macro-particles has been designed and tested in order to investigate the various parameters. Velocities to 7500 fps were achieved with an alumium projectile weighing approx 4.5 grams. Demangs to the projectiles became so	ISTRIBUTION LIMITATIONS: Nome; obtmin copies from DDC.	
Distribution LDMIATIONS: More; obtain copies from DDC, investigate the watkloss persenter for accelerating macro-particles has been designed and tested in order to Distribution to the profession of the series of the projection of the series of the projection of approx 4.5 great (mass losses to 40 percent) that the program was halted. Suggestions are made to the projection became so great (mass losses to 40 percent) that the program was halted. Suggestions are made to show bow the methods of accountical impedance matching could help prevent projectile break-up.	DISTRIBUTION LIMITATIONS: A single stage high explosive system for accelerating macro-particles has been designed and teated in order to DD free; obtain copies from DDC, investigate the westions parameters. Welocities to 7500 fee water achieved with an aluminum projectile weighing approve 4.5 grams. Damage to the projectile weighing approve 4.5 grams. Damage to the projectiles became so great (mass losses to 40 percent) that the program was	UNCLASSIFIED UNCLASSIFIED Necro-particle Acceleration Stapled Charges Stapled Charges Market Mc4-5-1, Jul 63, "A STUP OF MACES ACCESSION NO. PRAFICE Acceleration PRAFICE FOR Research, Palisablishis, Pa., 19137 Market Mc4-5-1, Jul 63 FRATION WITH SEQUENCE MIGH EXCESSION NO. PRAFICE FOR Research, Palisablishis, Pa., 19137 PARTICLE ACCELESION NO. PRAFICE FOR Research, Palisablishis, Particular Company of Maces Particular Acceleration for the Company of Particular Acceleration for the	UNCLASSIFIED UNCLASSIFIED VAD- NACCESSION NO PRANTOUN ASSEMAL, Besearch, Thiladephia, Par, 19137 Staples darges NAPTH NACO-PARTICLE Acceleration Management of Mana	UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED VACCESSION NO. Stagesticus for Margania and the properties weighing approx 4,5 gream. Demage to the projectiles became so great (mass losses to 40 percent) that the program was halted. Suggestions are made to show how the methods of acoustical impedance matching could help prevent projectile break-up. UNCLASSIFIED AD. AD. AD. AD. ACCESSION NO. FAMITY OF ASSIAL, Besearch and Dave Jopent Group, Pitnamban Internation and International Advancements of the Internation and International Advancements and International Advancement	DISTRIBUTION LIMITATIONS: More; Obtain copies from DDC, the water particles has been designed and tested in order to DiSTRIB investigate the various parameters. Velocities to 7500 from ware achieved with an aluminam projectile wighing approx 4.5 grams. Damage to the projectile became so grams (mass losses to do percent) that the program was halted. Suggestions are made to show how the method of accountical impedance matching could help prevent projectile break-up. UNCLASSIFIED AD- AD- AD- AD- AD- AD- ACCESSION NO. FAMATOR ASSIAL, Research, Thiladephia, Fa., 19137 Staplesive Boviess FAMETOR HISTRIBERS ACCEL- FAMING DE MASSIAL, Research, Thiladephia, Fa., 19137 FAMING DE MASSIAL ACCEL- FAMING DE M		In pp incl tables & illus; GMS Code 5520,11,434; DA Proj 50201008 Unclassified Report		s & illus; OMS Code 5520.11,434; DA Unclassified Report
III. Warren B. Forg. III. Warren B. Forg. III. Garen B. Forg. III. Ga	III. Warren B. Forg. III. Geren B. Forg. A single stage high arplosive system for accelerating macro-particles has been designed and tested in order to investigate the various primester. Velocities to 7500 fige ware achieved with an aluminum projectile weighing approx 4.5 grams. Damage to the projectile became so grams. Ross. Observed W. Forg. III. Warren B. Forg. A single stage high arplosive system for accelerating macro-particles has been designed and tested in order to investigate the various primester. Velocities to 7500 fige ware achieved with an aluminum projectile weighing approx 4.5 grams. Damage to the projectile became so grams (mass losses to 40 percent) that the program was bringled.	UNCLASSIFIED UNCLASSIFIED AD- ACCESSION NO. PRANTOUD ABSENT. Besearch and Days lithan burn institute for Research, Filladelphia, Fa., 19137 2. Shaped Charges	UNCLASSIFIED UNCLASSIFIED AD- ACCESSION NO. FRANKTORD ARGENAL, Research, Filled bling. Picnambun in the search and Dave toppen in the structure for Research, Thiladelphia, Pa., 19137 1. Shaped Charges	UNCLASSIFIED AD-ACCESSION NO. PRANTOD ASSMAL, Research and Development Group, Pitnant Dum Institute for Research of Research of Research of Laboration and Laboration and Laboration and Laboration of Accession No. **MANTOD ASSMAL, Research and Development Group, Pitnant Dum Institute for Research, Philadelphia, Pa., 1917 1. Stages Charges 2. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 1. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 1. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 1. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 1. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 1. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 1. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 2. Shaped Charges **MANTOD ASSMAL, Research, Philadelphia, Pa., 1917 **MANTOD ASSMAL, Research, Philadelphia,	DISTRIBUTION LINITATIONS: More; Obtain copies from DDC, investigate the various parameters, Welcities to 7500 None formerigate the various parameters, Welcities to 7500 None former achieved with an aluminam projectila weighing appent 4.5 grams. Damage to the projectila became so grant (mass losses to 40 percent) that the program was halted. Suggestrations are made to show how the mathods of acoustical impedance matching could help prevent projectile became to jectile break-up. UNCLASSIFIED AD-ACCESSION NO. FAMENTOED ABSEMAL, Mesearch and Dave lopment Group, Pitnam-L. Stapped Charges 2. Shaped Charges 3. Shaped Charges 4. Single the various passed charges and the search was bare former. Pitnam-L. Stapped Charges 4. Shaped Charges 4. Shaped Charges 4. Shaped Charges 5. Shaped Charges 6. Shaped Charges 6. Shaped Charges 7. Shaped Charges 8. Shaped Charges 8. Shaped Charges 9. Shaped Charges		FA ROT MG4-5-1, Jul 63, "A STUDY OF NACIO-PARTICLE ACCEL- RAVIOR WITH SUUDICED RICH REFLORED INTURES. Opeini- 		Jul 63, "A STUDY OF MACHO-PARTICLE ANCEL- NUMCED HIGH EXPLOSIVE DAVISES - Optimi- Stage Geometry," by Warren B. Fogs
1. Explosive Devices FA Mpt M64-5-1, Jul 63 Exation of Single Stage Geometry. Deviced-string Excepts Through Target Stage Geometry. By Warren B. Forg. II. Marren B. Forg. III. Marren B. Forg. IN PP Incl tables & Illus; GMS Code 5520.11.434; DA Proj 50201008 Unclassified Report A single stage high explosive system for accelerating macro-particles has been designed and tested in order to invest obtain copies from DDC. From Stage Stage Program A single stage high explosive system for accelerating macro-particles has been designed and tested in order to invest to which the system to approve 4.5 grams. Demage to the projectile became so gram depart and luminum projectile became so gram (and losses to 40 percent) that the program was hilted. Suggestions are made to show how the methods of accountical impedance matching could help prevent projectile break-up.	1. Explosive Devices 1. FA Rpt M64-5-1, Jul 63 1. FA Rpt M64-5-1, Jul 63 1. Marrian wire Strange Commercy." by Marrian Deviced - Optical - Strange Commercy." by Marrian Deviced - Definition of Single Strang Geometry." by Marrian D. Forgat III. Marrian D. Forgat III. Marrian D. Single Strang Geometry." by Marrian D. Forgat III. Marrian D. Single Strang Geometry." by Marrian D. Forgat III. Marrian D. Single Strang Geometry." by Marrian D. Forgat III. Marrian D. Marrian D. Single Strange Geometry." by Marrian D.	UNCLASSIFIED AD- ACCESSION NO.	UNCLASSIFIED AD- ACCESSION NO.	the were achieved with an aluminum projectils weighing approx. 4.5 great. Demags to the projectiles became so great (mass losses to the projectiles became so great (mass losses to the projectiles became so great can be seen to the projectiles became an	DISTRIBUTION LINUTATIONS: Mone; obtain copies from DDC, investigate the warious parameters. Valocities to 7500 fine were achieved various parameters. Valocities became so great (mass losses to 40 percent) that the program was halted. Suggestions are made to show how the methods of acoustical impedance matching could be prevent projectils break-up. UNCLASSIFIED AD- ACCESSION NO.		FIAMUPORD ALSEMAL, Research and Development Group, Pitman- Dunn Institute for Research, Philadelphia, Pa., 19137		From the Assert, Massarch and Mere topment oroup, stream Durn Institute for Massarch, Philadelphia, Pa., 19137
1. Mcro-particle Acceleration 2. Shaped Charges 3. Shaped Charges 3. Shaped Charges 4. Shaped Charges 5. Shaped Charges 7. Shaped Charges 1. TA Rep Mcd5-1, Jul 63. "A STUDY OF MACHO-PARTICLE ACEL. 11. Marren B. Fogs 11.	1. Mecro-particle Acceleration 2. Shaped Charges 3. Shaped Charges 1. TA Mpt 1845-1, Jul 63 "A STUDY OF MACE-PARTICLE ACCEL. 1. TA Mpt 1845-1, Jul 63 "A STUDY OF WAGNO-PARTICLE ACCEL. 1. TA MPT 1845-1, Jul 63 "A STUDY OF WAGNO-PARTICLE ACCEL. 1. TA MPT 1845-1, Jul 63 "A STUDY OF WAGNO-PARTICLE ACCEL. 1. TA MPT 1845-1, Jul 63 "A STUDY OF WAGNO-PARTICLE ACCEL. 1. TA MPT 1845-1, Jul 63 "A STUDY OF WAGNO-PARTICLE ACCEL. 1. TA MPT 1845-1, Jul 1845-1, Jul 1845-1, Jul 1845-1, Jul 1845-1, Jul 1845-1, Jul 1845-1, Ju			fps were achieved with an aluminum projectila weighing approx 4,5 grame. Damage to the projectila became so great (mass loses to 40 percent) that the program was halted. Suggestions are made to show how the methods of acoustical impedance matching could help prevent projectila break-up.	DISTRIBUTION LIMITATIONS: None; obtain copies from DDC, investigate the various praneter. Velocities to 7500 five warious prameter. Velocities to 7500 fips were achieved with an aluminum projecties became so great (mass loses to 40 percent) that the program was balled. Suggestions are made to show how the mathods of accoustical impedance matching could help prevent projectile break-up.	UNCLASSIFIED		UNCLASSIFIED	ACCESSION NO.
1. Explosive bavices 1. The Rev Net-1-1 Jul 63 1. Marring with Stagle Stage Generator, by Marren B. Pogs 1. Marring 1. Pogs 1. Marrin B. Pogs 1. Marring to Code 5350.11,434 1. Marring Distributions in the Code 5350.11,434, by Marren B. Pogs 1. Marring to Code 5350.11,434 1. Marring Edition Copies from Doc. 1. Marring	1. Replosive Devices 3. Replosive Devices 11. Agenthalian 11. Marrow B. Forg 11. Marrow D. Code 5250.11.434 11. One Code 5250.11.434 DISTRIBUTION I.MITAKIONS: 11. Marrow D. Code 5250.11.434 DISTRIBUTION I.MITAKIONS: 12. Shaped Charges 13. Replosive Devices 14. Marrow Devices 15. Shaped Charges 16. More particle Acceleration 17. Shaped Charges 18. Replosive Devices 18. Replosive Devices 19. Replosive Devices 19. Replosive Devices 19. Replosive Devices 10. More Cassifile Devices 10. More Cassifile Devices 11. Marrow Devices 12. Shaped Charges 13. Explosive Devices 14. Marrow Devices 15. Replosive Devices 16. More Devices 17. Marrow Devices 18. Replosive Devices 18. Replosive Devices 19. Replosive Devices 19. Replosive Devices 11. Marrow Devices 11. Marrow Devices 12. Shaped Charges 13. Explosive Devices 14. Marrow Devices 15. Replosive Devices 16. More Devices 17. Marrow Devices 18. Replosive Devices 18. Replosive Devices 18. Replosive Devices 19. Replosive Devices 11. Marrow Devices 11. Marrow Devices 12. Shaped Charges 13. Explosive Devices 14. Marrow Devices 15. Replosive Devices 16. More Devices 17. Marrow Devices 18. Replosive Devices 18. Replosive Devices 19. Replosive Devices 19. Replosive Devices 19. Replosive Devices 10. More Devices 11. Marrow Devices 11. Marrow Devices 12. Shaped Charges 13. Replosive Devices 14. Marrow Devices 15. Replosive Devices 16. Replosive Devices 17. Marrow Devices 18. Replosive Devices 18. Replosive Devices 19. R	II. TA MAY NAGES. OF THE STATE ACCEL. I. FA MAY NAGES. JUL 63 II. Harran B. Fogg III. GRS Code 5570.11434 III. OF COD	3. Explosive Devices PA Apt M64-5-1, Jul 63 EALING WITH STORMEND BINGER DEVICES ACCEL- 1. FA APR W64-5-1, Jul 63 EALING WITH STORMEND BINGER DEVICES - Optimi- 11. FA APR W64-5-1, Jul 63 EALING SEAR CHOMBERT, "By Warren B. FORG 111. GRS Code 5570-11,434 Proj 5021008 When I was a statement of Single Stage Geometry." By Warren B. FORG 114. Proj 5021008 When I was a statement of Single Stage Geometry. "By Warren B. FORG 115. Proj 5021008 When I was a statement of Single Stage Sta	3. Explosive Devices	3. Explosive Devices 94 and MACACAL 101 61 44 CTRIM OF MACHOLPARTICIES ACTRIL 1	1. RAPIONIUS Beiges 1. FA Rev M64-5-1, Jul 63 III. Warren B. Fogg III. ONS Code 5520,11,434 III. ONS LOG 5520,1106 DISTRIBUTION LIMITATIONS: None; obtain copies from DDC.	FA ROT MG4-5-1, Jul 63, "A STUPT OF MACRO-PARTICLE ACCEL- ZARIOW WITH STORMSCORD INCHES TO PRICESS - Optimization of Single Stage Geometry," by Warren B. Fogg Iw pp incl tables 6 illus; ORS Code 5520,11,434; DA Proj 50201006 Unclassified Report A single stage high explosive system for accelerating macro-particle has been designed and tested no refer to investigate the various parameters. Valocities to 7500 fps were achieved with an almainum projectile wighing approx 4,5 grams. Damage to the projectiles became so great (mass losses to 40 percent) that the program was builted. Suggestions are made to show how the methods of acoustical impedance matching could help prevent projectile break-up.	1. TA Bot Met-9-1, Jul 63 11. Marran B. Fogg 111. Marran B. Fogg 111. ONS Code 5570.11.434 10 Froj 50201008 105TRIBUTION LIMITATIONS: None; obtain copies from DDC. UNGLASSIFIED	Jul 63, "A STUNT OF WACRD-PARTICLE AGGEL- Stage Geometry," by Warren B. Fogg a & illus; QNS Code 5520.11.434; DA Unclassified Report Unclassified Report Unclassified Report Stage Been designed and tested in order to warious parameters. Valocities to 7500 d with an aluminum projectile weighing - Demags to the Projectile weighing of set to do percent) that the program was re made to show how the methods of ance matching coult help prevent pro-